Analysis and Design of Computational News Angles

IEEE Access
Multidisciplinary | Rapid Review | Open Access Journal

Received May 8, 2020, accepted June 8, 2020, date of publication June 29, 2020, date of current version July 14, 2020.

Digital Object Identifier 10.1109/ACCESS.2020.3005513

Analysis and Design of Computational News Angles

ENRICO MOTTA[1,2], (Associate Member, IEEE), ENRICO DAGA[2], ANDREAS L. OPDAHL[1], AND BJØRNAR TESSEM[1]

[1]Department of Information Science and Media Studies, University of Bergen, 5007 Bergen, Norway
[2]Knowledge Media Institute, The Open University, Milton Keynes MK7 6AA, U.K.

Corresponding author: Enrico Motta (enrico.motta@open.ac.uk)

This work was supported in part by the Norwegian Research Council IKTPLUSS, News Angler (collaboration with Wolftech AB, Bergen, Norway), under Project 275872.

ABSTRACT A key skill for a journalist is the ability to assess the newsworthiness of an event or situation. To this purpose journalists often rely on *news angles*, conceptual criteria that are used both i) to assess whether something is newsworthy and also ii) to shape the structure of the resulting news item. As journalism becomes increasingly computer-supported, and more and more sources of potentially newsworthy data become available in real time, it makes sense to try and equip journalistic software tools with operational versions of news angles, so that, when searching this vast data space, these tools can both identify effectively the events most relevant to the target audience, and also link them to appropriate news angles. In this paper we analyse the notion of news angle and, in particular, we i) introduce a formal framework and data schema for representing news angles and related concepts and ii) carry out a preliminary analysis and characterization of a number of commonly used news angles, both in terms of our formal model and also in terms of the computational reasoning capabilities that are needed to apply them effectively to real-world scenarios. This study provides a stepping stone towards our ultimate goal of realizing a solution capable of exploiting a library of news angles to identify potentially newsworthy events in a large journalistic data space.

INDEX TERMS Computational journalism, data schema, knowledge representation, news angles, ontology, reasoning components.

I. INTRODUCTION

A key skill for journalists is the ability to assess the newsworthiness of an event or situation. To this purpose, they typically rely on *news angles* [1]–[4] conceptual criteria that are used both to assess whether something is newsworthy and also to shape the structure of the resulting news item. Examples of common news angles in the journalistic literature include 'human interest', the local or community angle, impact (e.g., public or economical), celebrity, 'fall from grace', and others [3], [4]. Finding good *angles* on potentially newsworthy events and situations is therefore an important journalistic task, which needs to be better supported by journalistic software tools and platforms. However, although news angles and related concepts are well covered in the journalism literature on a general level, there has been so far only limited computational treatment of these notions, which has primarily focused on the automatic identification of the related notion of *news values*[1] in journalistic content [5], [6]. In particular, a comprehensive framework for representing and reasoning with news angles is still missing.

As a stepping stone towards addressing this gap, in this paper we analyse the notion of news angle from both a logical and a computational perspective and, in particular, we provide the following contributions: i) a formal framework and OWL[2] data schema for representing news angles; and ii) a preliminary analysis and characterization of a number of commonly used news angles, both in terms of our formal model and also in terms of the computational reasoning capabilities that are needed to apply them effectively to real-world scenarios.

[1]The notion of news value will be discussed in Section II, where we introduce the concept of news angle and compare and contrast it with other related concepts in the journalism literature.

[2]The Web Ontology Language (OWL) is a W3C standard for specifying ontologies on the Semantic Web – https://www.w3.org/TR/2012/REC-owl2-primer-20121211/.

The associate editor coordinating the review of this manuscript and approving it for publication was Seifedine Kadry.

From a methodological point of view, our contribution combines methods from ontology engineering [7] with an empirical approach, which focuses on identifying and analysing the specific news angles identified in the journalism literature [8].

This work is part of a longer-term effort aimed at developing a knowledge graph and reasoning architecture to support journalistic work. Our research group at the University of Bergen collaborates with Wolftech AB and, in the context of the joint News Angler project, we are developing News Hunter [9], an architecture and a series of prototypes, which aim to help news organisations to better harvest, organise and leverage social media streams and other big-data sources for journalistic purposes. A current central focus is to make the News Hunter platform big-data ready and, in particular, we aim to realise a solution that is capable of taking advantage of computational representations of news angles, both to identify potentially newsworthy events in large and live knowledge bases, and also to present them to journalists in terms of the conceptual models resulting from the application of these news angles to the events in question.[3] These conceptual models (which we call *fabulae* [10] – see Section IV for details) reflect the viewpoint introduced by the associated news angle and highlight the relevant facts that can provide the main building blocks of a novel news item.

The paper is organised as follows: Section II situates this contribution in the context of the broader area of computational journalism and compares and contrasts the notion of news angle with other relevant concepts in the literature. Sections III and IV introduce a characterization of news angles based on formal logic and define the main entities in our model. Section V discusses a number of news angles that can be found in the journalistic practice, characterizing them both in terms of our formal model and also in terms of the relevant computational reasoning capabilities that are needed to apply them to real-world scenarios. Section VI introduces an OWL vocabulary for representing news angles, which can be used to manage news angles in journalistic content management systems. In Section VII we consider the integration of our framework into concrete platforms to support journalistic work, by i) outlining the journalistic tasks enabled by a formal representation of news angles and then ii) providing a synthesis of the computational methods, which are needed to tackle the identified tasks. Finally, in Section VIII we summarise the main contributions of this work and outline the next steps that we plan to undertake in order to progress our research in this area.

II. BACKGROUND

A. COMPUTATIONAL JOURNALISM

Computational journalism is described in [11] as "the advanced application of computing, algorithms, and automation to the gathering, evaluation, composition, presentation, and distribution of news" (p. 180). Computational journalism augments *data journalism*, with its long tradition of using computers to acquire and analyse data for journalistic purposes, with a focus on computation and algorithms. Accordingly, [12] defines computational journalism as "information and knowledge production with, by, and about algorithms that embrace journalistic values" (p. 27).

Compared to earlier uses of ICT to support journalism, computational journalism is normally associated with one or more of the following characteristics [11]:

- widespread use by all types of journalists;
- using computers beyond data acquisition and validation, for example for news discovery, authoring, personalization, and interactive news presentation;
- advanced data-driven computation, focusing on computation and software as driving tools for creating journalistic content;
- computational thinking, i.e., applying computer-science concepts like abstraction, algorithm, decomposition, and pattern recognition to understand and solve complex problems.

Computational journalism can aim either to support journalists or to automate all or parts of news production. Examples of the latter include automated event detection [13], automated content curation [14], and robot writing [15]. In contrast with these approaches, our work implements primarily a view of computational journalism as a way to support journalists by relieving them from much of the low-level work of collecting, checking, and organizing facts.

B. NEWS ANGLES

Already several decades ago, [1] observed that reporters rely on 'angles' which "give the specific events new meaning" (p. 241), to which [8] added that "[a] predefined story 'angle' [...] provides reporters a theme around which to build a story" (p. 115), so that "facts are incorporated into stories rather than stories being based on facts" [16]. Hence, as already pointed out earlier, for a journalist the news angle serves a dual role: it offers i) a way to decide whether an event is newsworthy and also ii) an outline for reporting it.

A closely related concept is that of *news value*. In [17] the authors point out that news values can explain both "the apparent newsworthiness of an event or news actors to uncover why a story has been selected" and also "the organisational, cultural and economic factors that may also influence news selection" (p. 1472). They provide a list of 15 news values that a news story must generally satisfy to be considered newsworthy, including values such as conflict, surprise, the power elite, and celebrity.

Another related concept is that of *news frames*, which provide ways of understanding an event or issue by virtue of emphasizing some of its elements above others [18]. Frames are specific textual and visual elements - or 'framing devices' - that are essentially different from the other

[3] While this paper focuses on the automatic generation of news item templates through the application of news angles, it is important to emphasise that in practice, news items can also be produced as extensions or rebuttals of earlier news items, or they can concern a specific person, organization, or situation, regardless of whether any new event has actually taken place.

elements of a news story, which may be considered core news facts [18]. Through framing, the news media is not just amplifying issues, but also defining them for the public and actually articulating points of view on them [19]. Examples of common news frames in the literature are human impact, powerlessness, economics, moral values, and conflict.

Although the literature on news angles, news frames, and news values is contiguous and tightly interrelated, we consider news angles to be concrete and structured patterns for realising more abstract news values and ideological frames. For example, [17] lists stories that concern the *power elite*, ''powerful individuals, organisations, institutions or corporations'' (p. 1482), as a news value, but such a value offers no advice for how to structure stories about elites. Similarly, [18] cites the *powerlessness frame*, which emphasises the ''dominance of forces over weak individuals or groups'' (p. 56), but again this characterization is not sufficient to enable news reporting. In contrast, a news angle, such as *nepotism* [20], offers a concrete narrational pattern, according to which a *powerful person* who *controls* something of *value* makes that value *available* to a *relative*. Hence the news angle can be used not only to identify newsworthy events, but also to select the central facts to report about the event, in a way that fulfils both the *power elite* news value and the *powerlessness* frame (from the perspective of the reader without powerful relatives).

As different news organizations tend to emphasise different news values, it follows that a specific news angle may be more or less relevant to a given news organization, or that different news organizations may configure the same type of news angle differently. For example, what counts as 'local interest' would be considered differently in national and regional newspapers, while news angles to do with gossip and celebrities are likely to be much more relevant to Hello! magazine than to the Christian Science Monitor. In sum, while in general news angles can be characterised independently of a particular news organization, in practice their application depends on the values and priorities that are important for the news organization in question.

C. COMPUTATIONAL ANALYSES OF NEWS ANGLES

To the best of our knowledge, news angles have not yet been investigated in the research literature from a computational perspective, with the notable exception of the aforementioned work on automatic news classification with respect to news values [5], [6]. In the media industry, the IPTC's NewsML G2, EventsML G2, and rNews formats [21] and the BBC ontologies (https://www.bbc.co.uk/ontologies) offer standards for representing and exchanging news-related information; however, none of them considers news angles. There are also important ontologies for annotating information items, such as *Tag* [22] and *Meaning-of-a-Tag* (MoaT) [23], but, again, these do not consider news angles either. The Linked Open Data (LOD) cloud [24] also offers ontologies for representing events and for annotating information, such as news items. Notable examples for representing events are the *Event Ontology* [25], the *Simple Event Model* [26], and the *Event and (Implied) Situation Ontology* [27] used in the News Reader project. As discussed in Section III, the notion of Event is indeed a key building block of our ontological model and in particular we will base our representation of events on the aforementioned *Simple Event Model*.

III. REPRESENTING NEWS ANGLES

Consistently with the earlier analysis, we consider a news angle as *a generic conceptual template that fulfils both a classification and a design role*. From a classification point of view, a news angle provides a criterion that can be used to decide whether an event, or set of events, is potentially newsworthy and, if so, from which perspective [19]. From a design point of view, a news angle defines a design template providing a structure for how the event (or events) in question can be reported. Here, we build on basic concepts from literary theory [10] and, given a news report (the *narrative*), we distinguish *what is told* (the *fabula*) from *how it is told* (the *discourse*). In particular, we focus on how news angles can be used to suggest *what to tell* about events (*fabulae*), leaving out the potential influence of news angles on the discourse. We also focus on news reports written in terms of a single news angle, paying less attention to how news reports may combine multiple fabulae suggested by different news angles on the same event(s). To clarify these concepts, let's consider Tables 1 and 2, which list a number of angles that can be applied to two rather different sets of events, concerning a football match and a political appointment.

As shown by the examples provided in the two tables, the application of a news angle to a particular event typically relies on extensive additional knowledge about facts and events concerning the actors involved in the event in question. For instance, to apply the 'Triumph over Adversity' news angle to the event in Table 2, which concerns the appointment of Hassan Ali Khaire as Somali Prime Minister, an intelligent system would need to have access to additional information about Hassan Ali Khaire beyond his appointment as PM, in particular his fleeing of the civil war in Somalia in 1991.

We can minimally[4] characterise a news angle, say N, as a function that takes as input a set of events, and whose output is a set of fabulae, which provide the abstract structures of potentially newsworthy news items, generated by applying N

[4]We use the term 'minimally' to emphasise that this definition provides a baseline specification of news angle, focusing on its essential role as a mechanism for classifying events and associating them to fabulae. In practice, specific news angles may introduce additional parameters and, indeed, we have already pointed out that it is normal for news angles to be parametrised with respect to different organizations, which may subscribe to different news values.

TABLE 1. News angles that may be applied to a football match.

Event: Football team A beats team B 9-0.	
News Angle	**Headline Facts**
Impact	"Team B is now relegated and on the brink of bankruptcy"
Fall from grace	"Team B went from league winners to relegation in only 10 months"
Extremes	"This was the biggest league defeat ever for team B"
Prominence	"Star player in team A scores 4 goals"
Actionability	"Tickets still available for the next match of team A: buy them here"
Conflict	"Supporters of team B shout abuse at the coach and players"
Drama	"Team B player was unconscious for several minutes after clash of head with opponent"
Proximity/Local Interest	"Injured team B player is a local boy who grew up just down the road from our editorial office"
Milestone	"38 minutes into this match, team A became the first team ever in the league to reach 1000 minutes played without conceding a goal"
Human interest:	"Left midfielder who scored for team A played in honour of his terminally ill younger brother"
Celebrity	"George Clooney was in the stands watching the match"

TABLE 2. News angles that may be applied to an event concerning a political appointment.

Event: President Farmajo appoints Hassan Ali Khaire as new Somali PM	
News Angle	**Headline Facts**
Human interest	"Sheikh Ali was forced to leave his home country as a young man"
Proximity/Local Interest	"Hassan Ali Khaire has lived as a refugee here in Norway, in Vestre Slidre"
Triumph over adversity	"From refugee to Prime Minister"
Impact	"This appointment may strengthen democracy in Somalia and lead to progress and stability in the country"
Conflict	"Farmajo and Khaire's clans clashed during the southern unrest"
Unexpected	"Khaire was not thought to be a contender for this position"

to the set of input events. Crucially, the *event space* on which news angles are applied, is part of a larger knowledge base, *KB* that, among other things, contain information about the *actors* [26] involved in the events included in the event space.

To make these ideas more precise, we introduce the following axioms[5]:

```
(KnowledgeBase KB)                                                    (1)
(EventSpace ES)                                                       (2)
(forall (?event-set ?event-space)                                     (3)
    (if (and (EventSpace ?event-space)
             (member ?event-set ?event-space))
        (and (Set ?event-set) (every ?event-set Event))))
(forall (?event-set)                                                  (4)
    (if (and (member ?event-set ES)
             (member ?event ?event-set))
        (holds (Event ?event) KB)))
(forall (?event)                                                      (5)
    (if (holds (Event ?event) KB)
        (exists (?event-set)
            (and (member ?event-set ES)
                 (member ?event ?event-set)))))
```

The above axioms introduce a knowledge base, KB, and a space of events, ES. They also state that each element of an event space is a set of events and that each event included in this space is part of KB (def. 4). They also indicate that, for each event included in KB, say E, there is at least one event set in ES, of which E is a member. The statement (every *Set Type*) is verified if every member of *Set* is of type *Type*, while the statement (holds *Statement KB*) is verified if a logical statement, *Statement*, is true in a knowledge base, *KB*.

Having introduced our knowledge base and event space, we can then characterise a news angle as a function that takes as input a set of events and generate a set of fabulae as output. The axioms below define the notion of news angle and also characterise a fabula space as a set of sets of fabulae. Finally, the last axiom (def. 10) specifies that each fabula is associated to a specific news angle – i.e., the one that generated the fabula in question. The operator exists1 provides a syntactic shortcut to state that only one news angle can be associated to a specific instance of class Fabula.

```
(forall (?na) (if (NewsAngle ?na) (Function ?na)))                    (6)
(forall (?na) (if (NewsAngle ?na) (domain ?na EventSpace)))           (7)
(forall (?na) (if (NewsAngle ?na) (range ?na FabulaSpace)))           (8)
(forall (?fab-set ?fab-space)                                         (9)
    (if (and (FabulaSpace ?fab-space) (member ?fab-set ?fab-space))
        (and (Set ?fab-set) (every ?fab-set Fabula))))
(forall (?fabula)                                                     (10)
    (if (Fabula ?fabula)
        (exists1 (?news-angle) (hasNewsAngle ?fabula ?news-angle))))
```

IV. MODELLING THE MAIN ENTITIES IN OUR DOMAIN

Figure 1 provides an overview of the main entities in our model. As shown in the figure, in addition to the class

[5]In what follows, we use a notation based on the Common Logic (CL) standard [28], to specify the key elements of our model. However, for the sake of readability and in contrast with CL, we prefix variables with a question mark, to distinguish them from constants.

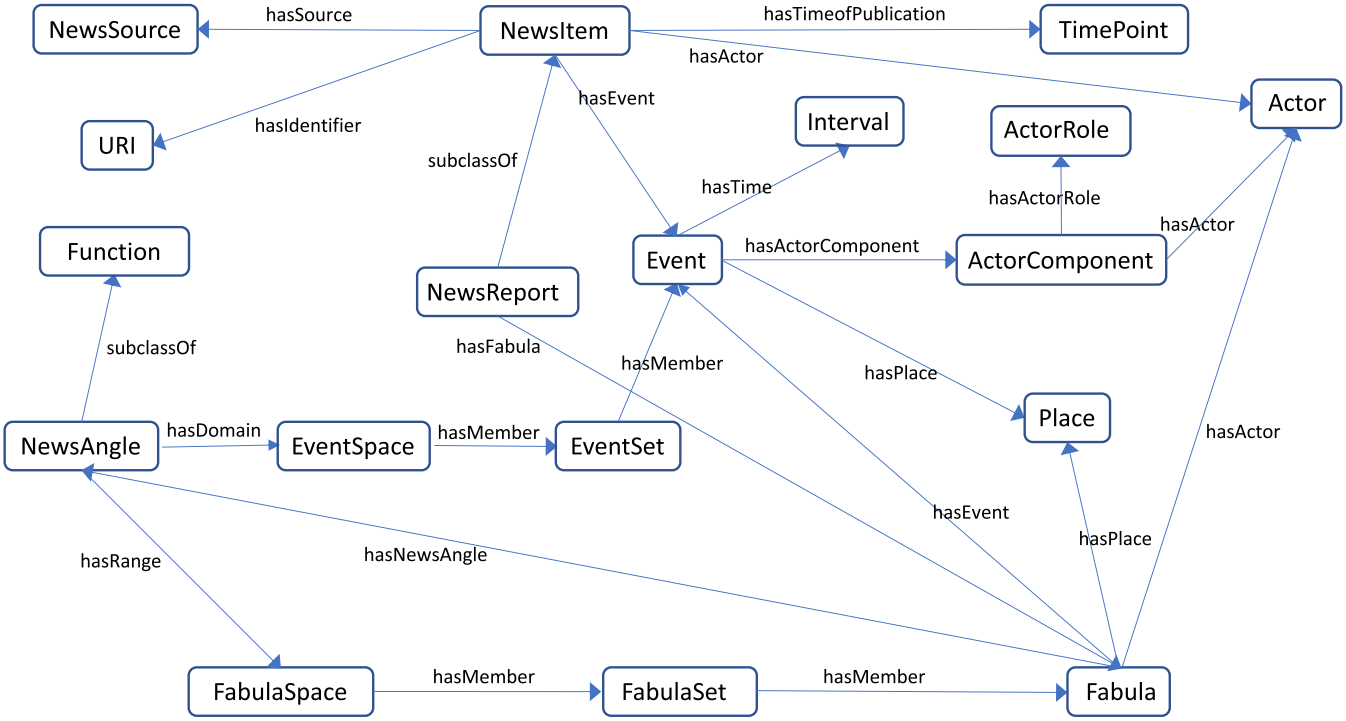


FIGURE 1. **Synoptic view of key classes and relations in our model.**

NewsAngle, our formalisation also includes the notions of *news item* and *news report*. The former refers to any potentially newsworthy piece of information, including for instance a tweet or a Facebook post, while the latter refers to a published piece of news that instantiates a specific fabula, and therefore reflects a specific news angle. The class NewsSource provides a generic term covering both traditional news sources (e.g., the New York Times), as well as social media (e.g., Twitter) and other information sources. All news items (and therefore also all news reports) are indexed with respect to a *time point*, i.e., are timestamped. In contrast with news items, *events* have instead a temporal extent, i.e., are mapped to an interval in time. Hence, our model makes use of the key distinction between time points (i.e., *instants*) and *time intervals*, which provides the basis of most time ontologies, including the OWL Time Ontology [29], the one used by our OWL data model for news angles, which will be presented in Section VI. Our model also includes the notion of *fabula*, whose instances are generated from the application of a news angle to a set of events. Hence, an instance of the class Fabula is characterised in terms of a news angle, a number of actors, a place, and one or more events. For example, the application of a proximity/local interest news angle, specialised for the Norwegian context, to the event concerning the appointment of Ali Khaire as Somali PM will produce an instance of class Fabula linked to the news angle and event in question and also related to a place, Norway, through a *hasPlace* relation.

In the model we build on the notion of event defined in the *Simple Event Model (SEM)* [26], where an event is characterised (among other things) in terms of the involved *actors*, *location*, and *time*. It is important to emphasise that an actor here can be almost anything, as events may concern individuals, groups of people, organizations, animals, planets, fictional entities, etc. The relation between events and actors is mediated by *actor components*, which characterise both the actors involved in the event in question and the role they play in the event. For example, the event concerning the appointment of Hassan Ali Khaire includes two actor components, the first one characterizing President Farmajo as the *appointing agent* and the second characterizing Hassan Ali Khaire as the *appointee agent.* Clearly distinguishing between these two roles is essential to enable the correct application of the relevant news angles, such as the 'Triumph over adversity' one, which, as a minimum, requires the identification of two events, one negative and one positive, concerning the same actor. In this case, it is important to distinguish between appointing agent and appointee, as normally a job appointment is considered a positive event particularly for the appointee. Hence, an engine looking for the application of 'Triumph over adversity' has i) to identify the two events concerning Hassan Ali Khaire, the earlier negative one to do with his fleeing of the civil war in Somalia and the later positive one concerning his appointment as Prime Minister, and ii) generate a fabula characterised in terms of the application of the 'Triumph over adversity' news angle to these events and actor.

Having now completed the definition of the essential building blocks of our model, we can proceed

in the next section to analyse a number of news angles.

V. COMMON NEWS ANGLES

Several researchers, such as [8], have listed common news angles used by journalists. Additional lists have been provided by practitioners [3], [4]. This section discusses a number of widely used news angles and illustrates how they can be characterised in term of our framework. Here we also outline the relevant reasoning capabilities that are needed to apply them effectively to real-world scenarios.

A. LOCAL INTEREST/PROXIMITY

This news angle emphasises that, as emphasised in [8], ''events that happen near are considered more newsworthy. Local events usually have more effect than distant ones. Local media seek local angles in national stories so as to better interest the audience'' (p. 106). [4] mentions the local angle, which ''describes how the local community or economy will be affected'', and distinguishes it from proximity, which ''relates a particular story (often warnings or advice) to a specific region [...]''. [3] explains a local element as ''most news organizations cover specific geographic ranges''. Indeed, as pointed out in Section II, both news angles in general and the Local Interest news angle in particular, are parametrised with respect to a particular organization. For example, an Iowa newspaper may report on a local charity event but is unlikely to report on a new condo development in Florida (unless, for example, a well-known Iowa entrepreneur is the development's lead investor). However, a national newspaper in the US may report on the Florida's condo development, for instance if a nationally important figure is associated with the development, or if this is significant enough from an economic or architectural point of view.

Hence, we can represent this news angle as a function that takes as input a set of events, a geographical location, and a news organization. The function identifies all events, which are relevant to the given geographical location and news organization, and then generates a set of fabulae using the relevant events and associated information (e.g., actors). For the sake of simplicity, we omit here the generation of the fabula, which tends to be pretty much the same for all news angles and we just focus our discussion on the task of identifying the events relevant to the news angle. In the case of the Local Interest news angle, this can be achieved by means of the following lambda expression[6]:

```
(lambda (?event-set ?place ?org)                                    (11)
    (setofall (?event)
        (and (member ?event ?event-set)
            (eventOfLocalInterest ?event ?place ?org)))
```

[6]Having characterised news angles as functions, in this section we use lambda expressions (i.e., anonymous functions) to represent them.

We can then partially define the relation *eventOfLocalInterest* by means of the following axiom:

```
(forall (?event ?place ?org)                                        (12)
    (if (and (Event ?event)
        (or (hasPlace ?event ?place)
            (and (hasPlace ?event ?place2)
                (within ?place2 ?place))
            (and (hasPlace ?event ?place2)
                (or (locallyRelevantNearbyPlace
                    ?place2 ?place ?event ?org)
                    (locallyRelevantRemotePlace
                    ?place2 ?place ?event ?org)))))
        (eventOfLocalInterest ?event ?place ?org)))
```

Here we assume that our knowledge base is able to reason about the *within* geospatial relation which specifies that a geographical location is a *feature parent* (https://www.geonames.org/about.html) of another one. Hence, the simple cases, where the event takes place in the area of interest (?place), or in a location (?place2) within the place of interest, can be easily accounted for.

Much more difficult is to handle the cases where the event takes place in a location which is neither the same nor within the default place of interest. As discussed earlier, in general, whether an event is locally relevant depends not just on geography but also on the event in question and the news values of the news organization. For these reasons it is not possible to give a complete definition of the relations locallyRelevantNearbyPlace and locallyRelevantRemotePlace and we limit ourselves to make some remarks about the heuristics that can be used to define whether an event is relevant to an organization who is connected to a particular geographical area.

In general, any important enough event, which would normally satisfy other news angles, would be 'locally relevant' to a national newspaper. In this case, journalists may stretch the definition of 'local' to include neighbouring countries, if the event is important enough. For instance, in the case of the crash of an Ukrainian plane in Iran, Norwegian newspapers emphasised the presence of Swedish nationals among the victims, as these provided the best local angle available. Analogously, in a hypothetical scenario of a major incident in a foreign base in Antarctica, which happens to be located near the Norwegian base, the local angle would simply be given by the proximity between the two bases, even though Antarctica is situated about 13,000 km from Norway! Generalising from these examples, we can say that in general an event may be of local interest with respect to a place, say p, either if it is near enough (and important enough), or if it involves local actors. While the definition of 'local' may be greatly expanded depending on the event in question, we can say that while local actors normally include all actors that live, work or were born near p, the set can be extended (for example) to include recursively all actors which have been

involved in an event which is of local interest with respect to p.

It is important to emphasise that the above definitions only capture explicit geographical connections between events and places. This type of local connection can be generalised by means of a *human proximity* news angle, which can be applied by relating ''a group or organization to an existing news event, usually describing how it's being affected by a previous announcement or occurrence'' [4]. In this case, the proximity could be social, cultural, or economic, rather than geographical.

B. HUMAN INTEREST

A large group of news angles includes a number of ways in which an event or situation can invoke human interest from the audience. Explanations of *human interest* in the literature include: ''people are interested in lots of things that don't have any direct effect on their lives: celebrities, political gossip, and human dramas. Stories with a human element elicit this kind of interest. That's why television news, in particular, illustrates issues through the people affected'' [8]. According to [4], *human interest* ''relates the story to social issues or discusses a person in an emotional way, as to generate interest or empathy in the reader''. We will here show models of the celebrity news angle and a more specific 'Triumph over adversity' news angle.

1) TRIUMPH OVER ADVERSITY

A particular type of human interest stories focus on highly dramatic trajectories, such a major disaster befalling a very successful person or, vice versa, success following major difficulties and struggles. Table 1 and 2 provide examples of these two types of trajectories, which correspond to the news angles labelled as 'Triumph over adversity' and 'Fall from grace'. In what follows we will focus on the representation of 'Triumph over adversity', as the other news angle can simply be represented as its opposite. This news angle can be modelled by means of the following lambda expression:

```
(lambda (?event-set)                                              (13)
    (setofall (?earlier-event ?later-event ?actor)
        (and (member ?earlier-event ?event-set)
             (member ?later-event ?event-set)
             (not (= ?earlier-event ?later-event))
             (hasActor ?earlier-event ?actor)
             (hasActor ?later-event ?actor)
             (eventPrecedes ?earlier-event ?later-event)
             (eventPolarityForActor
              ?earlier-event ?actor "negative")
             (eventPolarityForActor
              ?later-event ?actor "positive")))
```

This definition identifies all the triples $<$*?earlier-event, ?later-event, ?actor*$>$, where a negative event for a specific actor is temporally followed by a positive event for the actor in question.[7] Needless to say, this is a rather weak definition, as a sequence [negative event, positive event] does not necessarily fulfil the criteria for a 'Triumph over adversity'. More sophisticated definitions can therefore be considered. For example, we could require a sequence of events, where intermediate events are the explaining force of development from adversity to triumph, such intermediate events being essential to the suggested fabula. In addition, we could also try to assess the magnitude of the events in question and limit the application of the news angle only to events that are highly significant (in a positive or negative way) for the actor in question.

2) CELEBRITY

As pointed out in [17], the celebrity angle is frequently used in both the popular press and quality newspapers, providing ''Stories concerning people who are already famous'' (p. 1471). Its definition is quite simple compared to some of the others:

```
(lambda (?event-set ?place)                                       (14)
    (setofall (?event ?actor)
        (and (member ?event ?event-set)
             (hasActor ?event ?actor)
             (celebrity ?actor ?place))))
```

The last predicate checks if ?actor is a celebrity in a particular geographic context. This is because what constitutes a celebrity is highly context dependent, and in particular, celebrities tend to cover a specific geographical span. For example, the opening of a charity for youth with problems in Milton Keynes was attended by a renowned English footballer, Dele Alli, who is originally from Milton Keynes. The local newspaper journalist used the celebrity angle on the charity opening by focusing on Dele Alli in the title and in the first paragraph of the report.[8] The local connection, combined with international fame, makes Dele Alli a particularly important celebrity in Milton Keynes, enabling the use of the celebrity angle on this event.

Recognizing the celebrity news angle implies identifying people known from an existing background corpus [5] – for example, Wikidata or DBpedia, and linking them to relevant professions such as politician or actor. While this task is reasonably easy to perform using tools such as DBpedia Spotlight [30], more difficult is to assess the geographical scope of a celebrity. Here various heuristics may need to be defined – e.g., one such heuristic could involve assessing the level of fame of a celebrity in a particular field and then assessing the importance of the field in question in different parts of the

[7]Here it is important to emphasise that events are not necessarily positive or negative per se, but only in relation to a specific actor.

[8]https://www.miltonkeynes.co.uk/news/crime/dele-alli-pitches-steer-youths-away-knife-crime-milton-keynes-980039.

world. Such a heuristic, for example, would make it possible to compare the degree of fame of a top international cricketer and a top international football player in different countries, depending on the importance of cricket and football in the countries in question. Other heuristics could be based on statistical analyses – e.g., identifying mentions of the celebrity in question in the media coverage local to a particular geographic area.

C. CONFLICT

A conflict occurs when there are different accounts of or opinions about an event or situation. Here are some descriptions of *conflict* (or *controversy*) angles in the literature: ''Why are we so interested in controversy? It signals conflict and alerts us to important issues. Conflict is inherently more interesting than harmony. Maybe we assume that most of the time things are harmonious, but when they aren't we want to know about it'' [8]; ''It explains a controversy often with opposing viewpoints and positions'' [4]; and ''Reporters are professional storytellers, and good stories contain conflict. If you disagree with a competitor's approach, you're more likely to receive coverage than if you agree'' [3].

A subtype of conflict is 'David versus Goliath': ''Many stories have a 'big guy' and a 'little guy.' Because journalists often view themselves as the protectors of the exploited, the little guy usually receives more sympathetic coverage'' [3]. The 'David versus Goliath' angle adds human interest by invoking emotions in the audience.

As mentioned, a conflict news angle is often about conflicting opinions about a matter, e.g., opinions drawn from politicians belonging to different parties, or between politicians and activists. An example is the opening of the Norwegian oil field Johan Sverdrup in the North Sea. Greta Thunberg, famous international climate activist, and now a celebrity, argued that Norway should not do this due to the climate crisis, whereas the Norwegian energy minister, Sylvi Listhaug, argued that the opening is a good thing, since the oil field has record low emissions from the production itself, and the world is in need of oil anyhow. Note that the applicability of the conflict angle is often dependent on the status and relevance of the conflicting actors to the event. This may for example be a result of political power or, as in this case, of international fame through activism. It is also important to emphasise that there is no requirement that the actors are directly involved in the event in question, they can just express themselves, for instance, in a media interview or in a social media post. Such expressions will for consistency be considered events themselves, of type Opinion-event, a class which brings together a source, an opinion, and the event about which the opinion is given. The definition below illustrates the level of complexity that a Conflict news angle may have. A news angle may relate to several events involving many actors and other entities, and qualities about actors and entities in general.

```
(lambda (?event-set)                                              (15)
  (setofall (?event ?opinion-event1 ?opinion-event2)
    (and (member ?event ?event-set)
      (member ?opinion-event1 ?event-set)
      (member ?opinion-event2 ?event-set)
      (OpinionEvent ?opinion-event1)
      (OpinionEvent ?opinion-event2)
      (concernsEvent ?opinion-event1 ?event)
      (concernsEvent ?opinion-event2 ?event)
      (hasActor ?opinion-event1 ?actor1)
      (hasActor ?opinion-event2 ?actor2)
      (not (= ?actor1 ?actor2))
      (hasOpinion ?opinion-event1 ?opinion1)
      (hasOpinion ?opinion-event2 ?opinion2)
      (hasOpinionRelevance ?event ?actor1)
      (hasOpinionRelevance ?event ?actor2)
      (isConflicting ?opinion1 ?opinion2))))
```

As it is the case with many news angles, natural language analysis is essential for this kind of reasoning, to identify, extract and compare different opinions on the same event. In particular, recent studies suggest that the use of linguistic patterns provides better results compared to sentiment analysis in the context of mining opinions from text [31]. In addition, we can also use background sources, such as Wikipedia or Wikidata, to try and determine the relation between an actor and an event, to assess his/her relevance to the issue in question.

D. THE UNUSUAL

Unusual events or situations can be newsworthy in themselves. [8] explains that *the unusual* ''also interests us. We assume that the events of one day will be pretty much like the next, and the unusual is the exception to that rule'' (p. 106). [3] emphasises that ''stories with unexpected hooks are reporters' candy. If your study discovers that fried foods have previously undiscovered health benefits, you can bet the media will lavish you with coverage''. He also describes two special cases: *extremes or superlatives* — ''Reporters love extremes or superlatives: the first, last, best, worst, biggest, smallest. If your story contains one, highlight it to make your story more newsworthy''; and *milestones* — ''the seven billionth baby on Earth' was newsworthy, but 'the baby born just before seven billion and the one after were not newsworthy.' Some anniversaries are inconsequential — few journalists care that your business just celebrated its 35th anniversary — but others, such as Sept. 11th, will be noteworthy for decades to come''.

A surprising event that can be generalised occurred when Milton Keynes Council refurbished their offices.[9] This had a

[9]https://www.miltonkeynes.co.uk/news/politics/council/green-council-puts-moss-walls-inside-its-milton-keynes-hq-part-ps315000-office-refurbishment-1360300.

large cost, and a journalist had a story about a conflict about the use of public money for the refurbishment. However, this was not enough to catch the reader's interest, so the journalist focused on the use of preserved moss as the material for a large wall decoration. It makes sense to represent this story with the help of several events, the refurbishment as one event, the two interviews with opposing politicians as two events, and the decoration as a sub-event of the refurbishment. Very often it is not a larger event that is surprising in itself, rather it has some sub-events that have surprising properties. Here the moss decoration sub-event is the surprising element of the story. A definition of a surprise news angle, which focuses on the surprising sub-events associated with a larger event, is given below.

```
(lambda (?event-set)                                              (16)
    (setofall (?event ?surprising-event)
            (and (member ?event ?event-set)
                 (member ?surprising-event ?event-set)
                 (hasSubEvent ?event ?surprising-event)
                 (hasSurprisingElements ?surprising-event))))
```

In this case, we will need to check whether an event has surprising elements, i.e., actors, places, or other elements to it. This is a very general concept, hardly possible to model in a formal way. Instead we will need to do this by comparing events to other events with a similar context in a large event data base, to see if the combined elements of the potential ?surprising-event are not found there. Alternatively, one could use statistical search in stories found on the web – e.g., in [5] Wikipedia is used as background corpus, to check if combinations of elements are rare or non-occurring, like the ''moss as decoration'' element in our story.

E. IMPACT AND OTHER NEWS ANGLES

In addition to the news angles already discussed, there are a number of other news angles mentioned in Tables 1 and 2. We will not in this paper suggest models for these, but briefly discuss aspects of these news angles.

Arguably, the most important of these is what the literature describes as the impact angle. Reference [4] calls it *disaster*, which ''describes the impact of negative situations (and usually either what brought them about, how it's affecting the new subject, or what's being done about it)''. Reference [3] describes *an incident* as ''anything that goes wrong has the potential to become newsworthy, such as an industrial explosion, car crash or school shooting''. Reference [8] instead uses the term *prominence*, which is ''the importance of a story is measured in its impact: how many lives it affects. Fatalities are more important than property damage'' (p. 106). Notice that all these authors focus on what we may call negative events or situations, focusing on the event itself, the things that are negatively affected, how they are affected, and perhaps quantitative measures of the effect. Impact will have many subcategories, including *human impacts* (loss of life, physical injuries, and mental distress), *damage to infrastructure* (disruption to traffic), *damage to property* (broken cars), and *environmental impact* (oil spills, nuclear meltdown). Data sources for impact news angles may be very varied as they may include open public data, social media data, news reports. In order to estimate magnitude, information extraction engines are needed to identify numbers in the data, while sentiment analysis can be used to identify events that are particularly negative for specific actors, including large populations. For news value the impact has to be significant in size, and it also has to relate to other news angles, e.g., human interest and local interest.

Other news angles mentioned in the literature include:

- **Influence**: An influence event is newsworthy to the extent that it marks or shifts some well-known person's power or fame. Reference 8] calls it *importance*, ''actions of the powerful are newsworthy, because what the powerful do affects the general public'' (p. 106). Such effects are found when uncovering scandals, hypocrisy, incompetence, and repeated negative behaviour.
- **Recency**: These are angles that relate to the timeliness of an event [8]. News are almost always about recent events, however, they may also have the property of being related to some upcoming event or situation, like the start of a holiday period, or expected traffic problems due to upcoming weather situations. New developments connected to a newsworthy event may have news value, so the new development itself may itself be the news angle.
- **Actionability**: This news angle groups together *actionability, warnings and advice*, explaining that ''timely events are [...] more likely to require action''. Reference [3] mentions *clickability*, telling about how a report or a social media post is ''going viral''.

VI. OWL FORMALIZATION

In the previous sections we have introduced the key components of our model, using Common Logic to define our formal framework and to provide initial definitions for a number of news angles. Here, we introduce an OWL Vocabulary, the *News Angle Ontology (NAO)*, which provides a linked data model [24] for generating knowledge bases that are interoperable with our framework. Hence, the purpose of this OWL model is to provide a concrete resource enabling the exchange of information about news angles by different applications. NAO is published following the Linked Data principles and uses the namespace http://purl.org/news/angles/, which also provides the Web address of the ontology document.

As the structure of our OWL ontology closely follows the model already presented in Sections III and IV, we don't need here to describe it in detail, and therefore we will limit ourselves to highlighting the key decisions associated with the realization of the model in OWL. As shown in Figure 2, two classes specify the high-level notions that are necessary

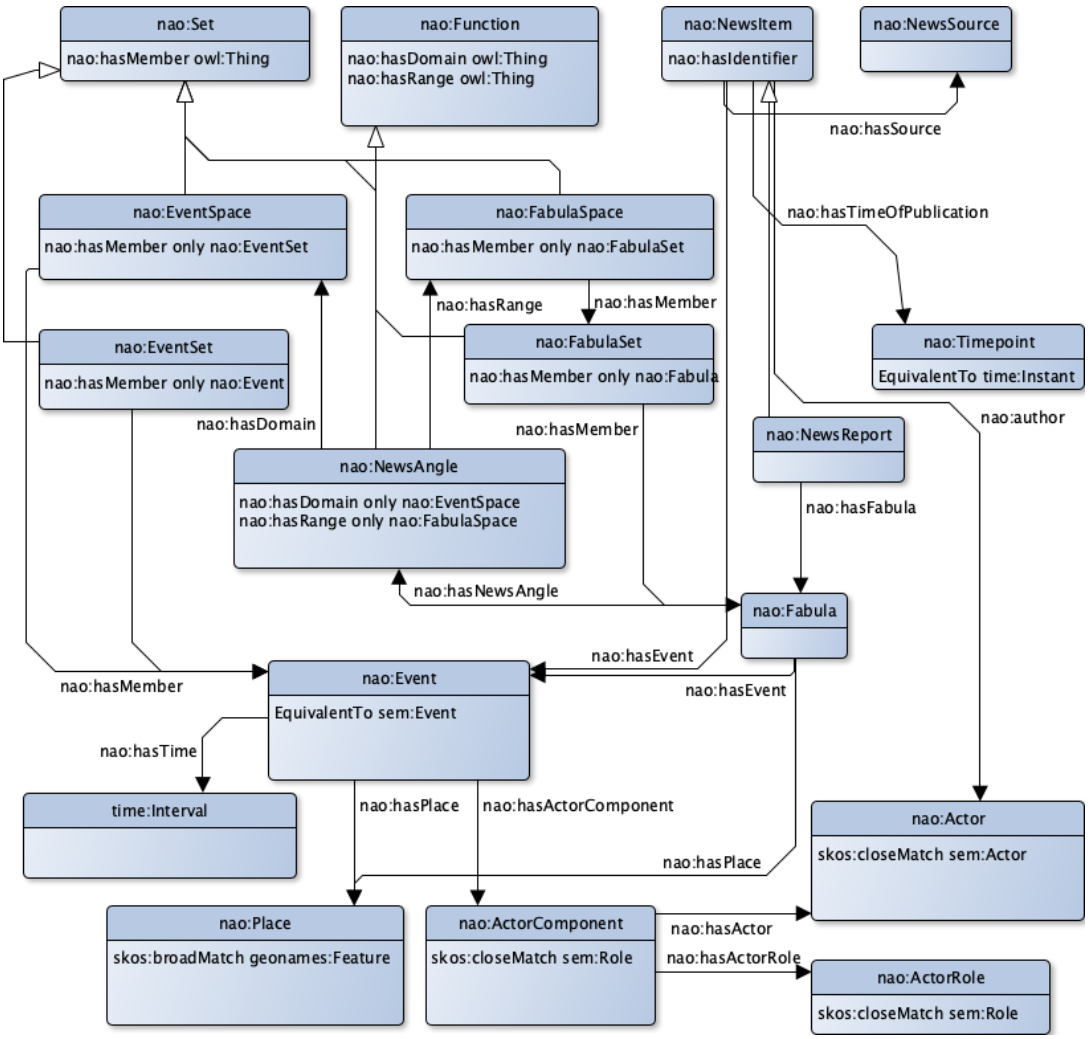


FIGURE 2. The News Angle Ontology in OWL.

for our model: `nao:Function`, which is needed to model news angles and `nao:Set`, which is needed to model different types of sets, including event and fabula spaces. Set membership is represented by means of the property `nao:hasMember`.

As already discussed in Section IV, a news report (`nao:NewsReport`) is a particular type of news item (`nao:NewsItem`), edited with respect to a particular journalistic viewpoint. In our ontology, news reports can have one (or more) `nao:Fabula`, each of them linked to a news angle by means of the property `nao:hasNewsAngle`.

NAO reuses concepts from three well-known Linked Data ontologies: Simple Event Model (prefix `sem:`), GeoNames (prefix `gn:`), and the W3C Time Ontology (prefix `time:`) for the representation of events, places, and temporal entities respectively. The alignment with these ontologies is performed either by using an OWL equivalence assertion (`owl:equivalentClass`) or a SKOS close match annotation property (`skos:closeMatch`). In particular, the ontology defines class `nao:Event` as equivalent to `sem:Event` and the class `nao:TimePoint` as equivalent to time:Instant. The ontology also aligns the three classes required for representing agents and roles using the `skos:closeMatch` annotation property: `nao:ActorComponent` is aligned to `sem:Role`, `nao:Actor` is aligned to `sem:Actor`, and `nao:ActorRole` is aligned to `sem:Role`.

The `time:hasTime` predicate associates time expressions to both events (with range defined as `time:Interval`) and news items (these are published at a `nao:TimePoint`). In the latter case, for the sake of readability, we specialise `time:hasTime` with `nao:hasTimeOfPublication`.

Finally, `nao:Place` is aligned with `gn:Feature`, a general class in the GeoNames ontology, which represents references to physical locations. By reusing concepts from SEM, GN, and Time, NAO supports a rich representation of events, time expressions, and places, while maximising interoperability with many existing ontologies.

VII. DISCUSSION

In this section, we discuss computational news angles from two complementary perspectives. First, we discuss the journalistic tasks enabled by a formal representation of news angles. This overview helps us to identify the requirements that a human-support system should satisfy at the *knowledge level* [32]. Later, these requirements will be discussed in the context of a knowledge engineering agenda.

A. SUPPORTING JOURNALISTIC COMPETENCE WITH COMPUTATIONAL NEWS ANGLES

1) AUTOMATIC FRAMING OF NEWSWORTHY EVENTS

The primary use of news angles is to support the identification of newsworthy events in a vast knowledge base, which includes several other key ingredients, such as location, participating entities, and their roles. Here we also assume that these are produced automatically, by mining a variety of sources, including both social media and traditional news agencies.[10] Within the proposed framework, newsworthiness assessment is therefore supported through the identification of potential news angles, which match a set of events in the knowledge base. Specifically, the envisaged system would aim to assess to what extent a set of events can instantiate the conceptual structure (i.e., the fabula) defined by one of the news angles in our library.

2) REPORT CLASSIFICATION AND THEMATIC ANALYSIS

Another core task is the identification and retrieval of news angles from reports and, by derivation, the classification of reports according to the adopted angles. This task can be seen as the inverse of the previous one and relates to the detection of news angles within a news report. Following our model, this would require the identification of a *fabula* in a news report, which corresponds to a relevant news angle. Clearly, a news report may be composed of multiple fabulae, generated from multiple news angles. Classifying news reports by news angles may enable some interesting analyses, for example comparing and contrasting the use of different news angles in different media sources, in the context of reporting on the same event, as well as identifying recurrent *themes* linked to the editorial agendas of different media outlets.

3) NEWS ANGLE TRANSFORMATION

By deconstructing the components of news items, news angles help discriminating the factual from the rhetorical content. As such, an AI system could use news angles to recommend the reframing of a news report. Such a system would first identify and extract the *events* included in the report. Then, the event data would be augmented from other sources – for example, details extracted from other news reports. Having done this, the task becomes one of determining whether news angles included in the library can be applied to the newly generated set of events, to produce *fabulae* that are different from the one structuring the report in question. As a result, it becomes possible to assess the event newsworthiness with 'fresh eyes' and consider the application of alternative news angles.

[10]In the News Angler project, we also carry out a number of other entity extraction tasks from news sources, in addition to event extraction, to generate a comprehensive knowledge graph of news-relevant entities.

B. A KNOWLEDGE ENGINEERING AGENDA

The analysis carried out in Section V allows us to extract the computational requirements that a news angle aware journalistic platform should cover and to sketch the basis for a library of methods to be developed to tackle the tasks discussed in the previous section.

1) EVENT EXTRACTION

A structured database of events is a critical resource for computational news angles. In loosely structured knowledge bases, or unstructured sources, such as textual corpora, the application of NLP plays a crucial role. The notion of *event* is typically characterised by a *key verb*, which establishes the connection between the involved agents and additional entities, such as people, places, and instruments involved [33], [34]. Event retrieval and extraction is extensively studied in domains such as Biomedicine [35], Finance and Politics [36], Science [37], and the Humanities [38]. Data-driven approaches to event extraction usually involve statistical reasoning or probabilistic methods [33]. In contrast, knowledge-based methods are generally top-down and based on pre-defined templates – for example, lexico-semantic [36] or graph patterns. These approaches can be combined, in particular by using machine learning methods to learn such patterns [39]. Typically, the same event can be expressed differently in the sources. To overcome this problem, one can build a dictionary of variants from a *core verb* and combine this with hints derived from external knowledge about the entities involved, such as, DBpedia – this is the approach developed in [40]. In addition, the various linguistic variants of the core verb also need to be harmonised, linking to authoritative vocabularies. For example, the core verb can be linked to a reference knowledge base of verbs, relying on resources such as VerbNet [41]. Through this mechanism, we can link events such as *Resign* and *Abdicate* to the unique general concept *Quitting* (in VerbNet). In the News Angler project, we aim to use information extraction techniques to annotate potentially news-related text items semantically and lift them into an evolving knowledge graph of events and related entities. Named Entity Recognition (NER) can be applied to characterise the various entities participating in the event, such as, agents (persons, organizations), locations (places, cities, nations), and time expressions.

2) NEWS ANGLES AND REASONING CAPABILITIES

Event extraction and modelling is only a prerequisite for reasoning with computational news angles. Table 3 summarises the news angles surveyed in this article and the relevant reasoning capabilities that may be needed to enable their

TABLE 3. Summary of news angles and associated capabilities.

News angle	Reasoning Capability
Local Interest	Named Entity Recognition (Places) Geo-Spatial Reasoner Qualitative Spatial Reasoner
Triumph over adversity (and its opposite)	Actor Polarity Reasoner Temporal Reasoner
Celebrity	Named Entity Recognition (Person) Background Knowledge (Person, Profession) Statistical Analysis (mentions of person or profession in geographically scoped media sources)
Conflict	Opinion Miner Actor Polarity Reasoner
The unusual	Common-Sense Evaluator Statistical Analysis
Impact	Amount of Effect Evaluator
Influence	Named Entity Recognition (Person) Background Knowledge (Person, Profession)
Recency	Temporal Reasoner Calendar Entity Recognition

effective application in the context of the envisaged computational journalism support.

Local interest requires reasoning on geo-spatial coordinates and boundaries in order to assess the relevance of an event to the location of the target audience. Notably, this applies to national or local newspapers but also to media on the Web, where the locality of an event may depend on the user's location or interest. Identifying named entities, such as, halls, schools, restaurants, cities or names of geographical points of interests is a necessary step for linking events and stories to well-formed geospatial coordinates. Reasoning with coordinates and distances is of paramount importance for the classification of events of local interest, where relevance is based on physical proximity. However, as discussed in Section V, local interest could be derived from qualities other than physical location – for example, by reasoning on events relevant to an organisation that belongs to a country (inclusion), or a product that was invented by a local entrepreneur and that is now produced in China. Clearly, many semantic relations can be reasoned upon in a spatial way. The need for developing spatial representations that are not quantitative (based on measures of distances) is common to many fields of artificial intelligence (AI), from robot navigation to visual intelligence and natural language understanding [42]. A qualitative spatial reasoner (QSR) could be applied to reason about notions such as inclusion, adjacency, and overlapping of boundaries [43], enabling associations between elements of the news, which are not typically considered spatially.

Triumph over adversity implies first of all the recognition of two events in which a person participated with opposing fortunes. Having done this, the system needs then to reason about temporal features in a qualitative way (in terms of *precedency* and *succession*) and compare the roles of the entity and the nature of the events in terms of positive or negative. Classifying the polarity of an actor in a situation can be seen as a specific form of sentiment analysis. Literature on sentiment analysis focuses on recognizing the sentiment associated to a phrase or paragraph with the aim of classifying people's opinions, sentiments, evaluations, and attitudes [44]. More specifically, the application of sentiment analysis to the news domain typically focuses on classifying the good or bad sentiment of the article towards the target [45]. In our case, we are interested in the fortune or misfortune of a subject of interest, which is rather different from evaluating the sentiment of a text, which is clearly derived from the expression of the content, not from the facts behind the content expressed. This seems to be a novel application area for sentiment analysis, aiming at developing a form of event-actor polarity reasoner.

As already mentioned in Section V, detecting a **Celebrity** may require a mix of methods, combining the use of background knowledge with a mix of named entity recognition and statistical analysis of geographically scoped news sources, to assess the celebrity status of an individual in a particular geographical location.

Classifying a news report from the point of view of the **Conflict** news angle requires instead a form of polarity detection, similar to the one discussed for Triumph over adversity. However, in the case of Conflict, one single event is shared by two entities with different roles (persons or organisations) and opposing polarity (opinion, sentiment, or attitude). Conflicts can also be implicit and derive from opposing opinions – for example, conflicting declarations of intent by opposing political parties. Recognizing, classifying, and linking opinions to entities is therefore crucial. However, current literature on opinion mining is more concerned with extracting opinions from natural language, rather than reasoning on a formal representation of events and actors. This opens up another interesting challenge.

Detecting the **Unusual** is an interesting case of a fuzzy classification task [46]. There can be several contextual reasons for events to be unusual. Here, the ability to analyse a very large corpus of events is crucial to detect rare situations [5]. More ambitiously, access to large scale domain and common-sense knowledge bases [47] could also help to identify automatically situations which are unusual.

Reasoning on **Impact** is a difficult problem that deals with identifying actions and targets (a NER task) but also the presence of a measure of effect of the action, for example, by means of quantitative qualifiers (''more than 300 dead in plane crash''). Relevant literature includes research on identifying violent or disaster events in the media by relying on language analysis [48], and also identifying and reasoning on qualitative expressions of quantities, which is an emerging research area in computer science [49].

Other news angles may require different capabilities. The **Influence** news angle relates to a change of state of a notable person. This angle combines the Celebrity concept with an association with two roles, which do not necessarily have

different polarities (and therefore do not instantiate a *Triumph through adversity* or *Fall from grace* news angles). Reasoning on Influence requires linking two or more events shared by a subject and reasoning on the similarities and differences. Similarly, determining the **Recency** of an event can be seen as an obvious task. However, some facts may be relevant in relation to specific events in the calendar of a country or local community. Background knowledge, such as Wikidata or DBpedia, could be of use here to determine how recurrent events within a community (Local interest) could be associated with the event under consideration.

To conclude, this discussion emphasises that computational news angles, although sharing the same conceptual schema, can be very different in nature and require different computational capabilities. This characteristic of news angles of being an *open domain* makes it crucial to have a common ontological definition, enabling systems (and humans) to define and exchange these knowledge objects within a common, well-defined, conceptualization.

VIII. CONCLUSIONS

In this paper we have reported on the initial outputs of our work on reasoning with news angles, which include a logical framework and an OWL data model to support the use of news angles in computational journalistic platforms. Our framework formally introduces news angles and related concepts and provides a data schema to support the generation of interoperable knowledge bases. In addition, we have also carried out a preliminary analysis and characterization of a number of commonly used news angles, in particular highlighting the key computational challenges that need to be tackled to ensure their effective application to real-world scenarios. The work presented here provides the basis for an architecture that is currently under development, which aims to support a number of the key tasks discussed here, including event extraction, effective modelling and implementation of a number of news angles, and their automatic application to live news feeds.

REFERENCES

[1] D. L. Altheide and P. K. Rasmussen, "Becoming news: A study of two newsrooms," *Sociol. Work Occupations*, vol. 3, no. 2, pp. 223–246, May 1976, doi: 10.1177/073088847600300206.

[2] O. M. Gallofré, L. Nyre, A. L. Opdahl, B. Tessem, C. Trattner, and C. Veres, "Towards a big data platform for news angles," in *Proc. Norwegian Big Data Conf. (NOBIDS)*, Trondheim, Norway, 2018, pp. 17–29.

[3] B. Phillips. (2014). *16 Story Angles That Reporters Relish*. [Online]. Available: https://www.prdaily.com/16-story-angles-that-reporters-relish/

[4] W. Upchurch. (2018). *Ten Common News Angles for Media Releases*. [Online]. Available: https://www.streetdirectory.com/etoday/ten-common-news-angles-for-media-releases-uuofou.html

[5] A. Piotrkowicz, V. Dimitrova, and K. Markert, "Automatic extraction of news values from headline text," in *Proc. Student Res. Workshop 15th Conf. Eur. Chapter Assoc. Comput. Linguistics*, 2017, pp. 64–74.

[6] E. Belyaeva, A. Košmerlj, D. Mladenić, and G. Leban, "Automatic estimation of news values reflecting importance and closeness of news events," *Informatica*, vol. 42, no. 4, pp. 527–533, May 2018.

[7] M. C. Suarez-Figueroa, A. Gomez-Perez, E. Motta, and A. Gangemi, Eds., *Ontology Engineering in a Networked World*. Berlin, Germany: Springer, 2012.

[8] P. J. Shoemaker and S. D. Reese, *Mediating The Message: Theories of Influences on Mass Media Content*. New York, NY, USA: Guilford Publications, 1991.

[9] A. Berven, O. A. Christensen, S. Moldeklev, A. L. Opdahl, and K. J. Villanger, "News hunter: Building and mining knowledge graphs for newsroom systems," in *Proc. NOKOBIT*, 2018, pp. 1–12.

[10] P. Gervas, "Computational approaches to storytelling and creativity," *AI Mag.*, vol. 30, no. 3, pp. 49–62, Jul. 2009, doi: 10.1609/aimag.v30i3.2250.

[11] N. Thurman, "Computational Journalism," in *The Handbook of Journalism Studies*, K. Wahl-Jorgensen and T. Hanitzsch, Eds., 2nd ed. Evanston, IL, USA: Routledge, 2019.

[12] N. Diakopoulos, *Automating The News: How Algorithms are Rewriting the Media*. Cambridge, MA, USA: Harvard Univ. Press, 2019, ch. 1.

[13] P. Vossen, R. Agerri, I. Aldabe, A. Cybulska, M. Erp, A. Fokkens, E. Laparra, A.-L. Minard, A. A. Palmero, G. Rigau, M. Rospocher, and R. Segers, "NewsReader: Using knowledge resources in a cross-lingual reading machine to generate more knowledge from massive streams of news," *Knowl.-Based Syst.*, vol. 110, pp. 60–85,Oct. 2016.

[14] M. A. DeVito, "From editors to algorithms: A values-based approach to understanding story selection in the Facebook news feed," *Digit. Journalism*, vol. 5, no. 6, pp. 753–773, Jul. 2017.

[15] N. L. Latar, "The robot journalist in the age of social physics: The end of human journalism," in *The New World of Transitioned Media*. Cham, Switzerland: Springer, 2015, pp. 65–80.

[16] S. Kline, "Creating reality: How television news distorts events," *Can. J. Commun.*, vol. 5, no. 3, pp. 36–39, Jan. 1979.

[17] T. Harcup and D. O'Neill, "What is news?: News values revisited (again)," *Journalism Stud.*, vol. 18, no. 12, pp. 1470–1488, Dec. 2017.

[18] C. H. D. Vreese, "News framing: Theory and typology," *Inf. Des. J. Document Des.*, vol. 13. no. 1, pp. 51–62, 2005.

[19] S. F. Wallington, K. Blake, K. Taylor-Clark, and K. Viswanath, "Antecedents to agenda setting and framing in health news: An examination of priority, angle, source, and resource usage from a national survey of U.S. Health reporters and editors," *J. Health Commun.*, vol. 15, no. 1, pp. 76–94, Feb. 2010.

[20] A. L. Opdahl and B. Tessem, "Ontologies for finding journalistic angles," *Softw. Syst. Model.*, vol. 19, pp. 1–17, Jun. 2020.

[21] R. Troncy, "Bringing the IPTC news architecture into the semantic Web," in *Proc. Int. Semantic Web Conf.* Berlin, Germany: Springer, 2008, pp. 483–498.

[22] R. Newman, D. Ayers, and S. Russell. (2005). *Tag Ontology*. Accessed: Apr. 7, 2006. [Online]. Available: http://www.holygoat.co.uk/projects/tags and https://web.archive.org/web/20060407215007/and http://www.holygoat.co.uk/projects/tags/

[23] A. Passant and P. Laublet, "Meaning of a tag: A collaborative approach to bridge the gap between tagging and linked data," in *Proc. LDOW*, 2008, pp. 1–5.

[24] C. Bizer, M. E. Vidal, and H. Skaf-Molli, "Linked open data," in *Encyclopedia of Database Systems*, L. Liu and M. T. Özsu, Eds. New York, NY, USA: Springer, 2018.

[25] Y. Raimond and S. Abdallah. (2007). *The Event Ontology*. Accessed: Sep. 23, 2019. [Online]. Available: http://motools.sourceforge.net/event/event.html

[26] W. R. van Hage, V. Malaisé, R. Segers, L. Hollink, and G. Schreiber, "Design and use of the simple event model (SEM)," *J. Web Semantics*, vol. 9, no. 2, pp. 128–136, Jul. 2011.

[27] R. Segers, P. Vossen, M. Rospocher, L. Serafini, E. Laparra, and G. Rigau, "ESO: A frame based ontology for events and implied situations," in *Proc. MAPLEX*, 2015, pp. 1–8.

[28] *Common Logic (CL)—A Framework for a Family of Logic-Based Languages*, Standard ISO/IEC 24707, 2nd ed, 2018.

[29] S. Cox and C. Little. (2017). *Time Ontology in OWL—W3C Recommendation*, Accessed: Oct. 19, 2017. [Online]. Available: https://www.w3.org/TR/owl-time/

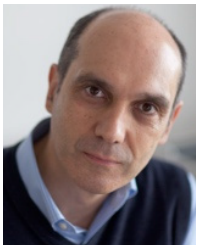
[30] P. N. Mendes, M. Jakob, A. García-Silva, and C. Bizer, "DBpedia spotlight: Shedding light on the Web of documents," in *Proc. 7th Int. Conf. Semantic Syst.*, 2011, pp. 1–8.

[31] B. Lin, F. Zampetti, G. Bavota, M. Di Penta, and M. Lanza, "Pattern-based mining of opinions in Q&A Websites," in *Proc. IEEE/ACM 41st Int. Conf. Softw. Eng. (ICSE)*, May 2019, pp. 548–559.

[32] H. Akkermans, H. F. van Harmelen, G. Schreiber, and B. Wielinga, "A formalization of knowledge-level models for knowledge acquisition," *Int. J. Intell. Syst.*, vol. 8, no. 2, pp. 169–208, 1993.

[33] F. Hogenboom, F. Frasincar, U. Kaymak, F. de Jong, and E. Caron, "A survey of event extraction methods from text for decision support systems," *Decis. Support Syst.*, vol. 85, pp. 12–22, May 2016.

[34] L. Huang, T. Cassidy, X. Feng, H. Ji, C. R. Voss, J. Han, and A. Sil, "Liberal event extraction and event schema induction," in *Proc. 54th Annu. Meeting Assoc. Comput. Linguistics*, vol. 1, 2016, pp. 258–268.
[35] J. Bjorne, F. Ginter, S. Pyysalo, J. Tsujii, and T. Salakoski, "Complex event extraction at pubmed scale," *Bioinformatics*, vol. 26, no. 12, pp. i382–i390, Jun. 2010.
[36] W. IJntema, J. Sangers, F. Hogenboom, and F. Frasincar, "A lexico-semantic pattern language for learning ontology instances from text," *J. Web Semantics*, vol. 15, pp. 37–50, Sep. 2012.
[37] M. Vargas-Vera and D. Celjuska, "Event recognition on news stories and semi-automatic population of an ontology," in *Proc. IEEE/WIC/ACM Int. Conf. Web Intell. (WI)*, 2004, pp. 615–618.
[38] E. Daga and E. Motta, "Challenging knowledge extraction to support the curation of documentary evidence in the humanities," in *Proc. 3rd Int. Workshop Capturing Sci. Knowl. Co-Located 10th Int. Conf. Knowl. Capture*, 2019, pp. 17–20. [Online]. Available: http://ceur-ws.org/Vol-2526/
[39] J. Piskorski, H. Tanev, and P. O. Wennerberg, "Extracting violent events from on-line news for ontology population," in *Proc. Int. Conf. Business Inf. Syst.* Berlin, Germany: Spinger, 2007, pp. 287–300.
[40] E. Daga and E. Motta, "Capturing themed evidence, a hybrid approach," in *Proc. 10th Int. Conf. Knowl. Capture*, Sep. 2019, pp. 93–100.
[41] K. K. Schuler. (Jun. 2006). *VerbNet: Extensions and Mappings to Other Lexical Resources*. [Online]. Available: https://tinyurl.com/qmragts
[42] A. G. Cohn and J. Renz, "Qualitative spatial representation and reasoning," *Found. Artif. Intell.* vol. 3, pp. 551–596, 2008. [Online]. Available: https://www.sciencedirect.com/bookseries/foundations-of-artificial-intelligence/vol/3
[43] C. Freksa, "Qualitative spatial reasoning," in *Cognitive and Linguistic Aspects of Geographic Space*. Dordrecht, The Netherlands: Springer, 1991, pp. 361–372.
[44] B. Pang and L. Lee, "Opinion mining and sentiment analysis," *Found. Trends Inf. Retr.*, vol. 2, nos. 1–2, pp. 1–135, 2008.
[45] A. Balahur and R. Steinberger, "Rethinking sentiment analysis in the news: From theory to practice and back," in *Proc. WOMSA*, 2009, pp. 1–12.
[46] J. Roubos, "Learning fuzzy classification rules from labeled data," *Inf. Sci.*, vol. 150, nos. 1–2, pp. 77–93, Mar. 2003.
[47] R. Speer and C. Havasi. (2012). *Conceptnet 5. Tiny Transactions of Computer Science*. [Online]. Available: https://tinyurl.com/yx4d6xjj
[48] H. Tanev, J. Piskorski, and M. Atkinson, "Real-time news event extraction for global crisis monitoring," in *Proc. Int. Conf. Appl. Natural Lang. Inf. Syst.* Berlin, Germany: Springer 2008, pp. 207–218.
[49] R. Subhro, T. Vieira, and D. Roth, "Reasoning about quantities in natural language," *Trans. Assoc. Comput. Linguistics*, vol. 3, pp. 1–13, Jan. 2015.



ENRICO MOTTA (Associate Member, IEEE) received the Laurea (Master-level degree) in computer science from the University of Pisa, Italy, and the Ph.D. degree in artificial intelligence from The Open University. He is currently a Professor in knowledge technologies with The Open University. He also holds a professorial position at the Department of Information Science and Media Studies, University of Bergen, Norway. He is also the Head of the Intelligent Systems and Data Science Research Group, KMi. His work spans a variety of research areas to do with large-scale data integration and modeling, semantic and language technologies, intelligent systems and robotics, and human–computer interaction. He has authored over 350 refereed publications and his H-index is 66. Together with Tom Heath, he won the Semantic Web Challenge at the 2007 International Semantic Web Conference and, in collaboration with members of his research group, the Best Paper Award at the 2008 and 2009 Asian Semantic Web Conference. Over the years, he has advised research institutions and governments in several countries, including U.K., USA, China, The Netherlands, Austria, Finland, and Estonia. He was the Editor-in-Chief of the *International Journal of Human-Computer Studies* from 2004 to 2018. In 2003, he founded the ground-breaking European Summer School on Ontological Engineering and the Semantic Web (SSSW), which provided the main international postgraduate forum for learning about semantic technologies until its final edition, in 2016.

ENRICO DAGA received the Ph.D. degree in artificial intelligence. He has carried out research on web semantics and ontology engineering first at the Italian National Research Council (CNR) and then at the Knowledge Media Institute, The Open University (OU), U.K. After playing key roles in projects related to the development of intelligent systems for Ontology Engineering (NeOn) and Smart Cities (MK: Smart), he currently leads the OU Linked Data initiative and the MK Data Hub, a platform to support R&D for data-intensive applications in smart cities and cultural heritage. His current research is exploring the application of knowledge-based methods to support scholarship in the humanities and developing novel data curation pipelines through intelligent processing of license and policy metadata.

ANDREAS L. OPDAHL received the Ph.D. degree from the Norwegian University of Science and Technology. He is currently a Professor of information systems development with the Department of Information Science and Media Studies, University of Bergen, Norway. He is the author, coauthor, or coeditor of more than a hundred peer-reviewed research articles. His research interests include ontologies and knowledge graphs, enterprise and IS modeling, as well as safety and security requirements. He is a member of the IFIP WG5.8 on Enterprise Interoperability and WG8.1 on Design and Evaluation of Information Systems. He serves regularly as a Reviewer for premier international journals and on the program committees. He serves as an organizer of renowned international conferences and workshops.

BJØRNAR TESSEM was born in Steinkjer, Norway, in 1961. He received the B.S., M.S., and Ph.D. degrees in informatics from the University of Bergen, Norway, in 1983, 1985, and 1990, respectively.

He has been an Associate Professor and a Full Professor in information science with the University of Bergen (UoB), since 1991 and 1999, respectively. He was a private IT consultant, from 2000 to 2004. He has been a Professor with UoB since 2002. He is currently an Adjunct Professor with the Department of Strategy and Management, Norwegian School of Economics, Bergen. His main research interests include artificial intelligence (natural language processing, analogical reasoning, and Bayesian networks), information systems, and software engineering. He has authored more than 100 scientific articles in a variety of fields and is a regular reviewer in high-quality conferences and journals.